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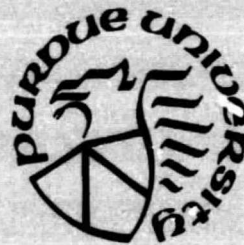
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(NASA-CR-173848) MEASUREMENT OF THE
ABSORPTION COEFFICIENT USING THE
SECOND-INTENSITY TECHNIQUE (Purdue Univ.)

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A STUDY OF METHODS TO PREDICT AND MEASURE THE TRANSMISSION OF
SOUND THROUGH THE WALLS OF LIGHT AIRCRAFT

Research Contract #0226-52-1288

MEASUREMENT OF THE ABSORPTION
COEFFICIENT USING THE
SOUND-INTENSITY TECHNIQUE

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MEASUREMENT OF THE ABSORPTION COEFFICIENT USING THE SOUND-INTENSITY TECHNIQUE

1. INTRODUCTION

The absorption coefficient of a material is a measure of the fraction of incident energy absorbed by the material. Numerous methods of measuring the sound absorption coefficient have been described over the years. There are two basic methods which measure the change in the reverberation time and the standing wave ratio in a tube, and from these quantities, the random incident and the normal incident adsorption coefficient are respectively calculated. These methods are very time consuming and the analysis has to be carried out at each frequency of interest. Both methods are also subject to several limitations. The deficiencies of the reverberation methods are well known and the errors involved can be ascribed to the assumptions made in the derivation of the reverberation formula not being achieved in practice. In the case of the wave tube, it is assumed that only plane waves propagate in the tube, and this is only true if the wavelength is greater than 1.7 times the tube diameter. Also, only relatively small samples of the material can be investigated and, hence, effects which depend upon the dimensions and edge conditions cannot be investigated.

Since the widespread use of sound intensity measurements, several researchers and organization have suggested the possibil-

ity of measuring the absorption coefficient by measuring the intensity incident on the sample and the net intensity reflected by the sample. In the present study the possibility of using the intensity technique to measure the adsorption coefficient is investigated. Results obtained by this technique are compared with the standard techniques.

1.1 Measurement of Normal Incident Absorption Coefficient

The normal incident absorption coefficient of two different samples was measured using the standard technique and the intensity technique. The two samples consisted of 2 inch fibreglass and 1 inch fibreglass with a thin paper facing. These samples, it was felt, represented the wide range of absorption coefficients encountered in practice, and would suggest if the technique could be applied to low as well as high absorption coefficient materials.

1.2 Standard Technique

The normal incident absorption coefficient of the two samples was measured using the B&K standing wave apparatus. The absorption coefficient was measured for the frequency range 125 Hz to 2000 Hz in increments of 1/3 octaves.

1.3 Sound Intensity Technique

The sample under study was mounted on a steel panel and the net intensity in front of the sample was measured. The net intensity (I_f) in front of the sample was considered to be the sum of the intensity incident (I_i) on the sample and the intensity reflected (I_r) by the sample.

$$I_f = I_i - I_r \quad (1)$$

The intensity incident on the sample was measured by removing the sample and the mounting panel and measuring the intensity over the same area as was previously occupied by the sample. Special care was taken to make sure that the area used for the measurement of incident intensity was the same in size and distance from the sound source as the area used for the measurement of the net intensity in front of the sample. For this purpose a string grid supported between 2 poles was used to outline the position of the sample under investigation. The absorption coefficient (α) was then calculated using the expression

$$\alpha = \frac{I_f}{I_i} \quad (2)$$

Half-inch phase-matched field-incidence microphones, arranged side-by-side with 13.2 mm spacing were used to measure the intensity. The output signals from the microphones was passed through measuring amplifiers and anti-aliasing filters before being fed to the FFT, where the data was recorded as nar-

row 10 Hz bandwidth measurements. With the help of a specially written fortran program, it was possible to convert the data into one-third octaves if required. The intensity was measured by sweeping the two-microphone array as close as possible to the sample.

1.4 Measurement of the Random Incident Absorption Coefficient

In this part of the study only one sample was investigated namely 2 inch fibreglass.

1.5 Standard Technique

The random incident absorption coefficient of the sample was calculated from the change in the reverberation time as a consequence of placing the fibreglass in the reverberation chamber using the expression

$$\alpha_s = \alpha_r + \frac{0.049V}{S} \left(\frac{1}{T_{rs}} - \frac{1}{T_r} \right) \quad (3)$$

where α_s is the absorption coefficient of the sample, α_r is the average absorption coefficient of the reverberation chamber, V is the volume of the reverberation chamber S is the area of the sample, T_r is the reverberation time of the empty room, T_{rs} is the reverberation time of the chamber with 72 square feet of fibreglass placed in the middle.

The reverberation time of the chamber was measured using a specially written program on the FFT. The details of the meas-

urement procedure have already been discussed in an earlier report (1).

1.6 Sound Intensity Technique

The intensity incident on the sample was assumed to be given by the diffuse field intensity

$$I_i = \frac{P_{rms}^2}{4\rho C} \quad (4)$$

where P_{rms}^2 is the space averaged rms sound pressure in the reverberation chamber, ρ is the density of air and C is the speed of sound in air. The sound pressure in the empty chamber was measured using a half-inch microphone rotating on a boom. To account for slight variations in the chamber, measurements were taken at four different locations in the room and an average value was calculated.

The absorption coefficient of the sample was calculated using Eq. (2) and as such the net intensity in front of the sample I_f ($I_i - I_r$) was measured by sweeping the microphone close to the fibreglass placed in center of the chamber.

2. RESULTS AND DISCUSSION

Figures 1 and 2 show the comparison between the normal incident absorption coefficient measured using the standard technique and the intensity technique for the case of 2 inch

fibreglass and 1 inch fibreglass respectively. As can be seen fairly good agreement is observed at higher frequencies. However, the agreement is very poor at low frequencies. This agreement may be due to the fact that at low frequencies the sheet on which the samples were mounted would be a very poor reflector unlike the heavy backing used in the standing wave tube.

Figure 3 shows the comparison between the random incident absorption coefficient of 2 inch fibreglass measured using the standard technique and the intensity technique. Once again fairly good agreement - observed at high frequencies. The cause of the low frequency discrepancy at this stage is uncertain.

3. REFERENCES

1. Atwal, M.S. and Bernhard, R., "Prediction of Light Aircraft Interior Sound Pressure Level Using the Room Equation", Her-
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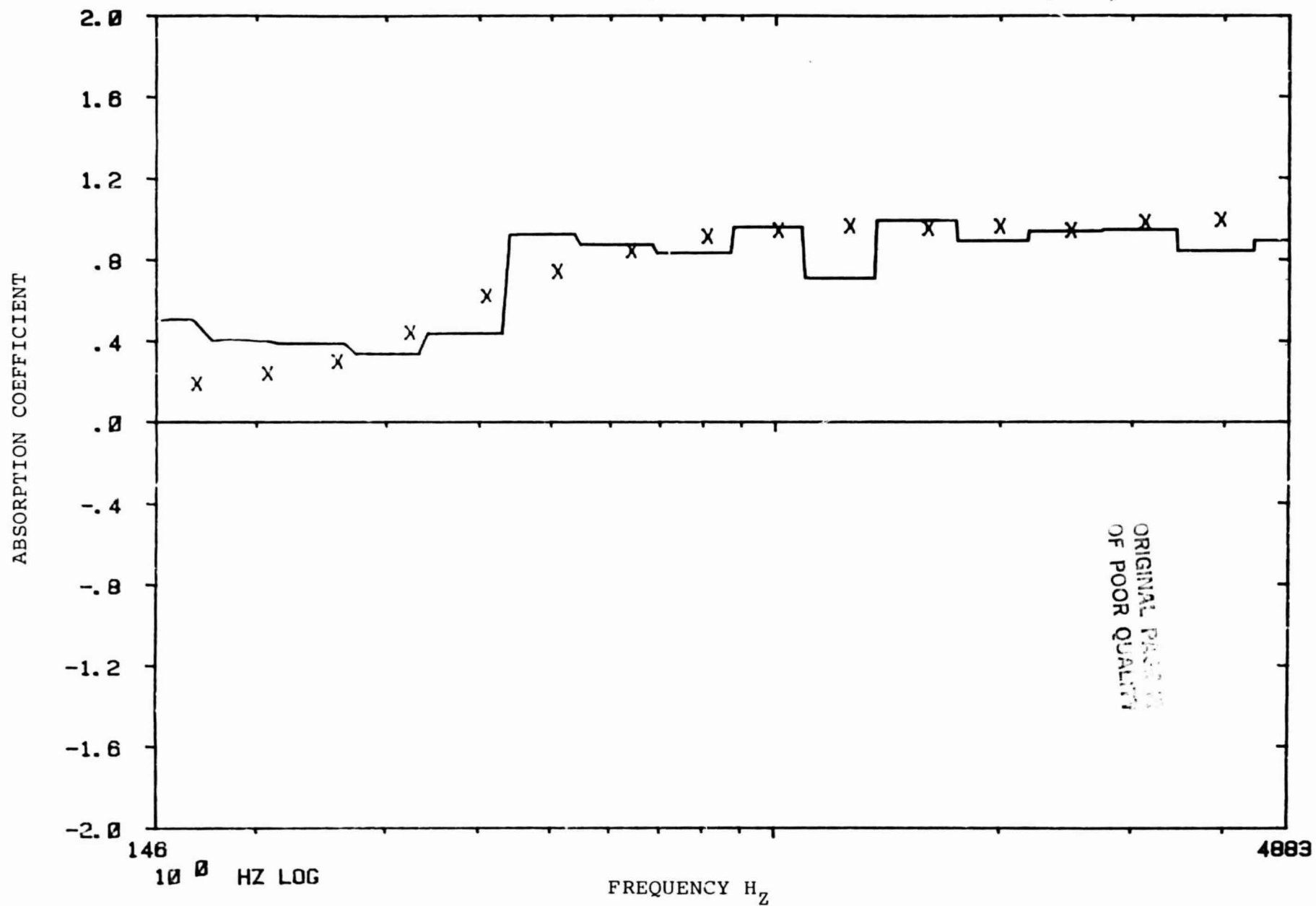


Figure 1. Measured normal incidence absorption coefficient of 2 inches fibreglass (x standard technique, — intensity technique).

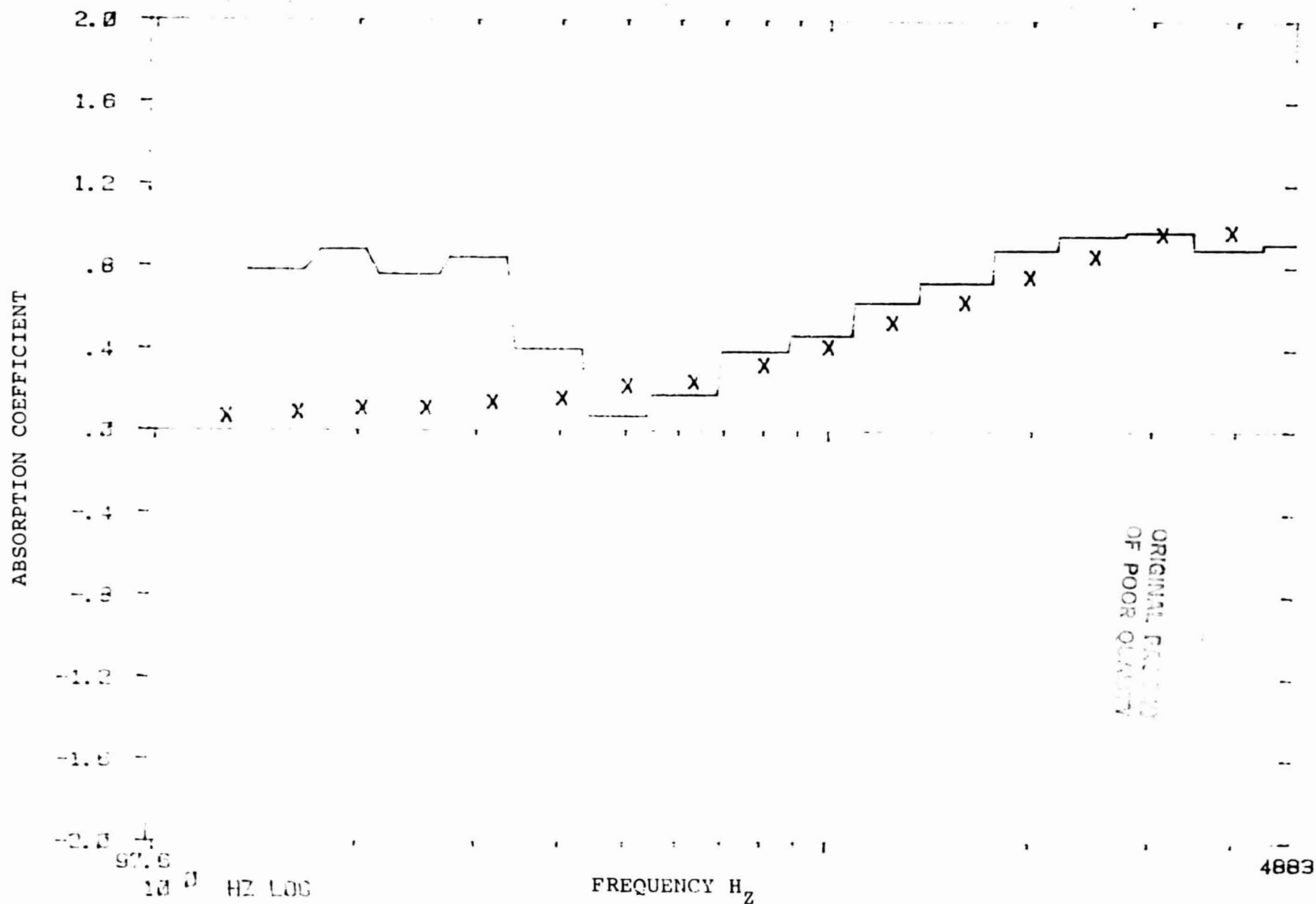


Figure 2. Measured normal incidence absorption coefficient of 1 inch fibreglass (x standard technique, — intensity technique).

ABSORPTION COEFFICIENT

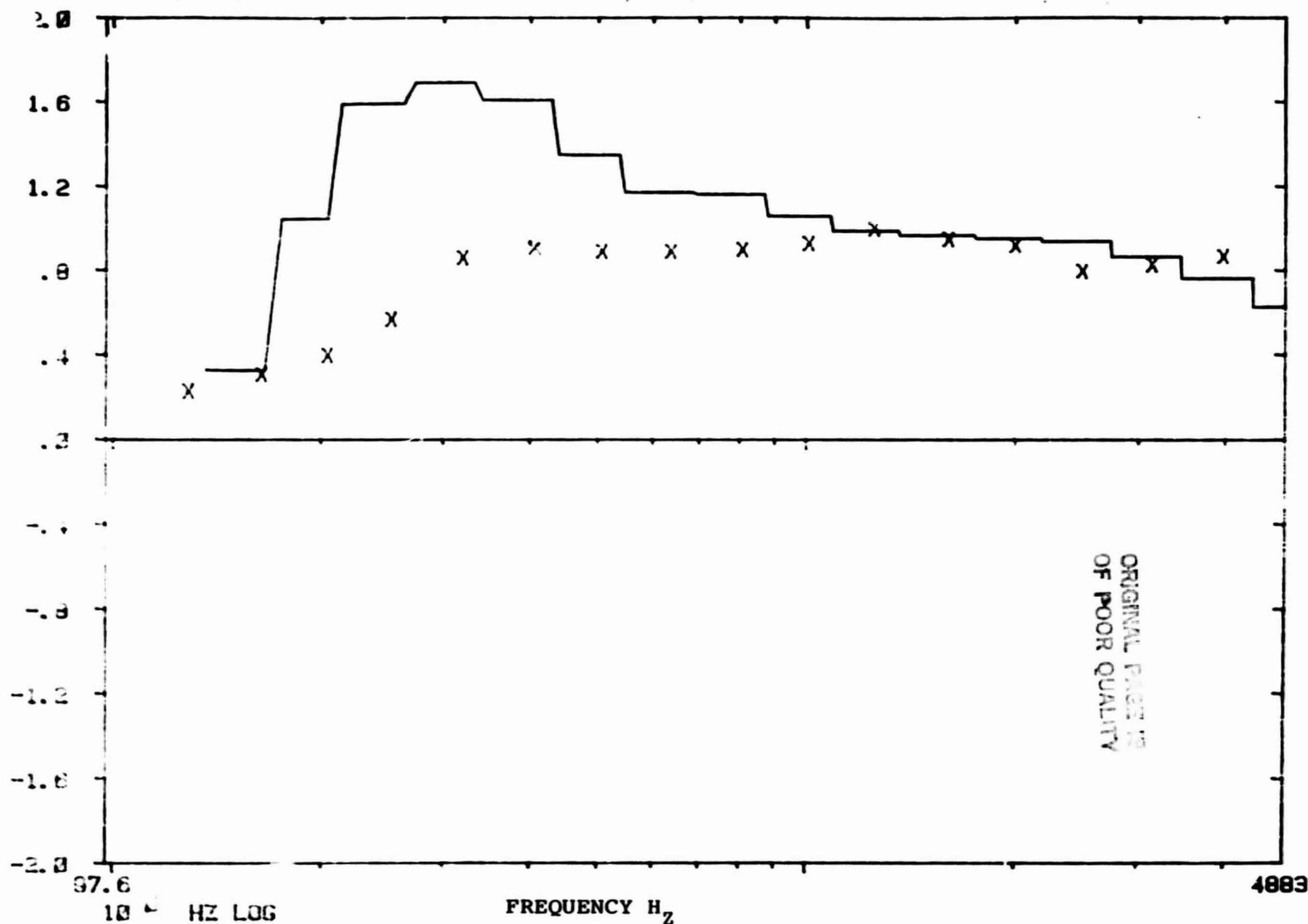


Figure 3. Measured absorption coefficient of 2 inch fibreglass (random incidence) (x standard technique, — intensity technique).